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FAILURE ANALYSIS OF CHANNEL 1 MONOPULSE SECONDARY SURVEILLANCE RADAR IRS 20 MPS

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Abstract

Radio Detection and Ranging (Radar) is an electromagnetic wave used to monitor the movement of a moving object. RADAR will get information about the height and distance of an object by utilizing electromagnetic waves. Radar is surveillance equipment to monitor the aircraft's position in the environment around the radar up to a radius of *± 250 NM. This article aims to analyze the surveillance facility at Kualanamu Airport Monopulse Secondary Surveillance Radar (MSSR) INDRA. This paper uses an exploratory study method with descriptive qualitative research to investigate and trace the problem. The problem on the INDRA IRS 20 MPS Radar is offline due to PLN supply maintenance activities, causing the supply voltage on the radar to be unstable. The failure problem on MSSR is due to damage to the Sum Amplifier Unit (SAU) module, which causes the SUM output on the Radar to be abnormal. The result of channel 1 INDRA IRS Radar 20 MPS operation can operate again after replacing a new SAU module. The conclusion of the operation of channel 1 INDRA IRS Radar 20 MPS can operate normally again after the replacement of a new SAU module.*

Keywords: *radio channel, failure, surveillance radar*

Introduction

In order to ensure flight safety, it is supported by flight observation services consisting of several pieces of equipment operated by Air Traffic Controllers, such as Primary Surveillance Radar, Monopulse Secondary Surveillance Radar (MSSR), Air Traffic Service Automation, Automatic Dependent Surveillance-Broadcast, Advanced Surface Movement Guidance and Control System (A-SMGCS), and other observation equipment (Bestugin et al., 2020). Purpose of flight traffic services, a) Prevent collisions between aircraft in the air, b) Prevent collisions between aircraft or aircraft with obstacles in the maneuvering area, c) Facilitate and maintain the regularity of flight traffic flow, d) Provide instructions and helpful information for flight safety and efficiency, e) Provide notifications to relevant organizations for search and rescue assistance (Kireina et al., 2022; Li et al., 2020).

The crucial flight traffic services are from the succinct explanation above. Radar is a mentioned instrument in Indonesia for managing air traffic. Radar can build maps of items like airplanes, cars, and weather data in addition to serving as a way of identifying target positions and being able to contain extra information in the form of target identification, azimuth, altitude, and direction (Nishitani et al., 2019; Purwaningtyas et al., 2022; Zhang et al., 2019). However, what happens if the radar range does not cover the air traffic control area? Of course, it is hazardous for flights. Regarding aviation, displaying more than one radar sensor at an airport is possible. The number of radar sensors displayed is beneficial for air traffic controllers to carry out their duties more optimally (Simamora & Caesar, 2022). MSSR is a system to obtain accurate measurements of the angle of incoming and received signals from radar stations. The name comes from determining the signal's angle from one reply pulse. In SSR systems with monopulses, there is an additional signal known as a difference beam (Δ channel), so it requires three receivers to process information, namely to receive Δ channel, Ω channel, and Δ channel (Minteuan et al., 2021a).

MSSR IRS 20 MPS is a radar system used for air traffic control purposes (Minteuan et al., 2021). A failure analysis of this system would involve identifying and analyzing any issues or problems that may have occurred with its operation. Some potential causes of failure in the MSSR system could include hardware malfunctions, software bugs or errors, signal interference or other environmental factors, or human error. Gathering data and information about the system's behavior leading up to and during the failure event is essential to perform failure analysis. This may involve reviewing system logs, analyzing sensor data, and conducting interviews with operators or other personnel involved with the system.

This research analyses the problem that occurs on the INDRA IRS 20 MPS Radar is offline due to PLN supply maintenance activities, causing the supply voltage on the radar to be unstable. Then technicians went to the location to turn on the radar and found a "Sum Output Power Failure" alarm on Channel 1, resulting in Channel 1 radar not operating. After checking, the measurement value of the Sum Amplifier Unit (SAU) module is abnormal, and there is an anomaly at each power level. The technician then dismantled the SAU module and found the SAU module on fire. The result of channel 1 INDRA IRS Radar 20 MPS operation can operate again after replacing a new SAU module.

Methods

This research aims to obtain data to provide answers to specific problems and then find the desired conclusions through a qualitative approach. This is an exploratory study (Franciosi et al., 2020; Mahrami & Christina, 2021) with descriptive qualitative research to investigate and trace the problem. Investigate and trace a problem using scientific work carefully and thoroughly to collect, process, analyze data, prevent a problem, or test a hypothesis to obtain helpful knowledge for human life.

The data collection techniques include observation, interviews, and document studies (Rijal, 2021). The types of data collection techniques are as follows: first, an interview is a way to collect research data by conducting interviews or questions and answers face-to-face orally between interviewers and interviewees to obtain information needed in research. Researchers need a second observation and recording of facts. Observation is the basis of science because scientists work based on data and facts about the world of reality produced through observational activities.

Third, literature study is a method by collecting data by understanding and studying theories from various literature related to the research. The data collection uses how to find sources and construct from various sources such as books, journals, and research that has been done. Literature material obtained from various references is analyzed critically and must be considered in order to support its propositions and ideas (Nina et al., 2022).

Results and Discussions

An essential function of maintenance management is where the organization's economic worth is governed by maintenance management, which is a crucial component (Ali M & Kusuma, 2019; Chen et al., 2019; Franciosi et al., 2020). The term "maintenance management" describes the activity of steering and directing an organization through the use and management of its resources, including its financial, human, material, intellectual, and technological assets (Ceruti et al., 2019; Manesi, 2015).

In order to reach an organization's financial goals, it is necessary to prioritize maintenance management through all means of planning, directing, implementing, and regulating, as well as numerous improvement techniques. The idea emerged from this research to analyze the failure of channel 1 of the MSSR INDRA IRS 20 MPS Radar at Kualanamu Airport. Here is the block diagram of MSSR INDRA. The explanation of the diagram block is divided into the transmitter process, receiver process, and extractor process, which are as follows:

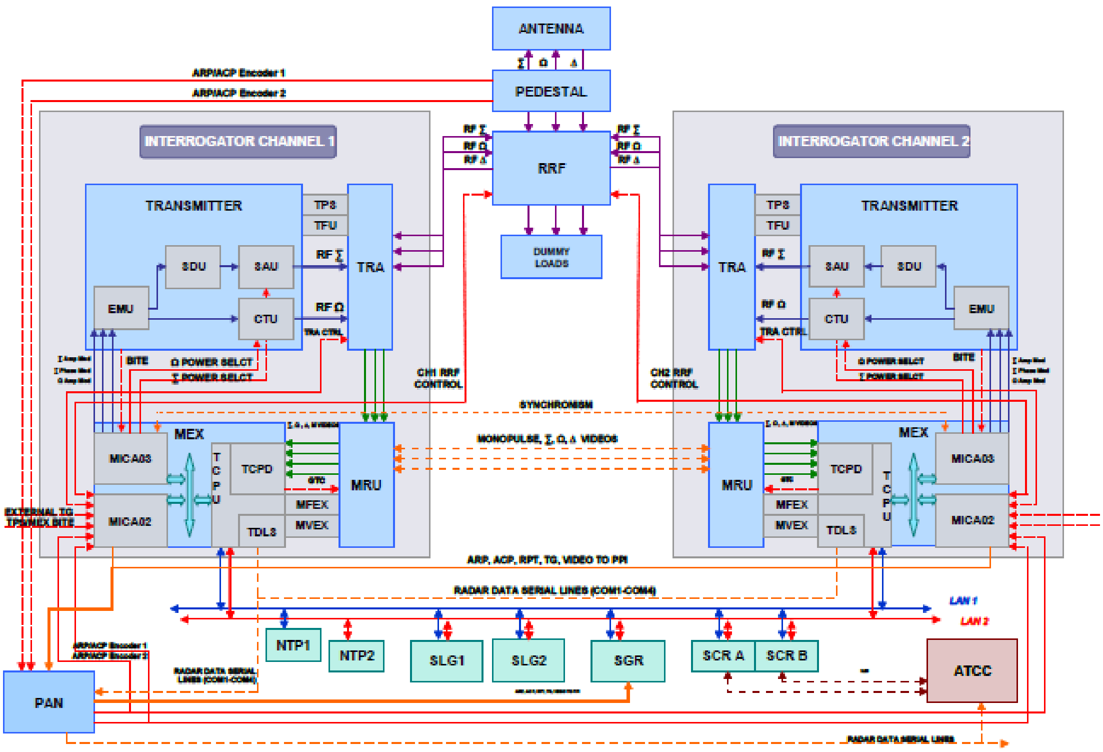

Figure 1. INDRA MSSR block diagram

All signal processing on this sensory radar starts from MICA 03, which generates synchronization signals (triggers) on the radar from internal triggers with varying PRF or external triggers. It is also set the duration of the Interrogation Gate, Video Gate, Stagger Time, and Death Time to complete the minimum total time for the interrogation cycle. (PRT). Sensory radar also generates modulation signals required for interrogators (1, 2, 3/A, intermode and S mode). After that, it configures the transmitter's power during interrogation to the SUM and OMNI channels (Aulia et al., 2013). It functions as a BIT transmitter and receptor. It has Azimuth Table for easily changeable parameters depending on sector settings for power transmission, ISLS function activation, activation of the BLANKING function, and activation of interrupt application via VME bus to change azimuth sector, then to enter the transmitter section (TX).

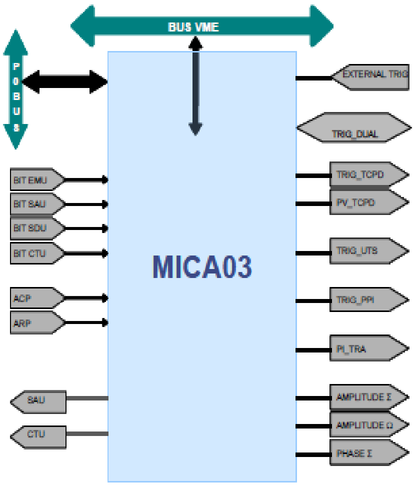

Figure 2. MICA 03

Second step continue to Exciter Modulator Unit (EMU), where three signals, namely Omni, Sumface, and Sum amplitude are combined and amplitude strengthened. For Sum, it becomes 42 dB, and Omni becomes 62 dB. After that, the signal is differentiated/broken into two paths: Sum to SDU and Omni to CTU. In the Sum Driver Unit (SDU), the Sum signal, which was 42 dB, was again amplified to produce a 62 dB signal. The Sum Amplifier Unit (SAU) is where the last Sum signal amplification produces 65 dB. So just like that in SAU, the same function as SDU is to strengthen the signal.

The Third step is the Control Transmitter Unit (CTU), where CTU is the place of Omni signal amplification. So in this CTU, the Omni signal, which was 62 dB after entering the CTU signal, is strengthened to 65 dB. After the transmitter, proceed to TRA. The fourth step continues to Transmitter – Receiver Antenna Interface Unit (TRA). The primary function of the TRA module is to forward the RF signal with a passive circulator. In transmission, TRA forwards power output at 1,030 MHz for SUM and OMNI channels to the antenna. While in the reception process, TRA forwards the reply signal received at 1,090 MHz for SUM, OMNI, and DIFF channels to MRU. In TRA, it is also a filter to get the desired frequency. In addition, TRA also has a circulator where this circulator is to determine the TX and RX to be used(Abdullah et al., 2021).

Then the fifth step is Radio Frequency Switch (RRF). The RF switch can be seen in Figure 4. The RF switch has three four-port coaxial L band relays. It provides a switchover between the two channels to keep the main channel connected to the antenna and the standby channel connected to the dummy load. RRF gets 12 vdc redundant power from MEX, only MEX 2 in the main condition. RF relays need supply. If channel 1 is off, channel 2 can set up the RF relay; if channel 2 is off, channel 1 is not required to set up the relay. And here also as a determinant of MAIN and Standby. The Main will be transmitted through the antenna, and the standby will go into the dummy load (Minteuan et al., 2021b).

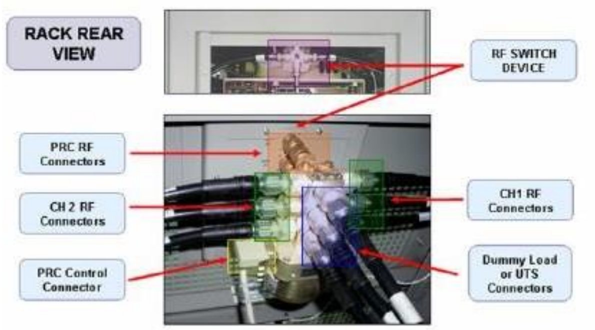

Figure 3. RF switch

MEX and commands from UCS implement this relay control, and this control can be Automatic if the UCS application requests switchover due to detection failure or degradation of all main channel supervision parameters and manual if the user manually requests switchover via the UCS application. Usually used for maintenance, it can be minted locally or remotely.

In the event of a failure in the main channel, the switchover will be performed at least 259 ms from the confirmed failure. Switchovers are passive components that require no maintenance. The sixth step continues to PEDESTAL. PEDESTAL is a producer of Encoder. Here also acts as a motor measuring the movement of the antenna in order to produce ACP ARP. And then the seventh step is Rear Connections Panel (PAN). The rear connection panel (PAN) is an interface panel that connects external triggers to MSSR Mode S racks. PAN consists of elements: Additional circuit breakers, AC Connector, Antenna Drive System Rotation Connector, GPS timer connector, Encoder connector, Serial path connector, Graphic system connectors, and External trigger line connector.

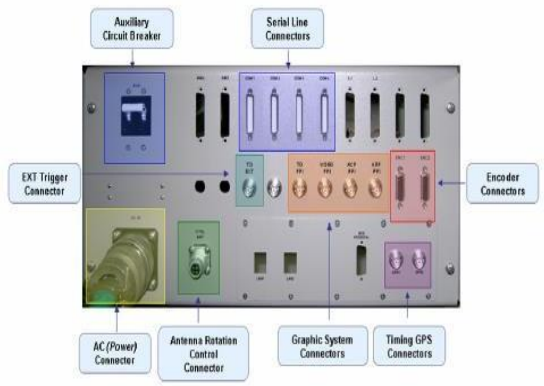

Figure 4. Rear connections panel

The last step continues to MICA 02. Main Functions of MICA 02 Firmware: Encoder interface and BITE, ARP delay for north setting, Control Time Azimuth Table, Antarmuka UTS absolute Time Counter, and PPI interface. Main functions of MICA 02 P0BUS: Fast and accessible connection between TCPD, MICA 02, and MICA 03, MICA 02 is a board that regulates access to the bus. This allows access to SWGENIST on TCPD to Time Azimuth Once from MICA 02, and the signal is ready to be transmitted through the antenna. Process radar receiver where the antenna receives three input signals, SUM, OMNI, and DIF, and enters the TRA. As explained earlier, he will filter to get the frequency we want in TRA. Moreover, the circulator found in the TRA determines its TX and RX.

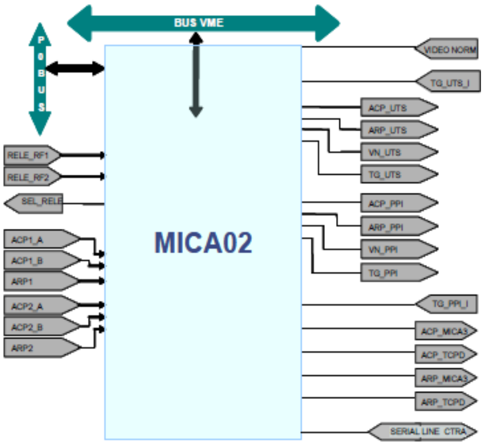

Figure 5. MICA 02

The problem researchers face is the maintenance from PLN on the main supply of PT. ANGKASA PURA II Kualanamu Airport, however, PLN's supply maintenance activities on electricity lines 1 and 2 were not on the agreed schedule, causing the supply voltage on the radar to be unstable. Then the technician checked and found the INDRA IRS 20 MPS Offline Radar report. Then the technician went to the location to turn the radar back on after the live radar found the alarm "SUM OUTPUT POWER FAILURE" on Channel 1, resulting in the Channel 1 radar not operating.

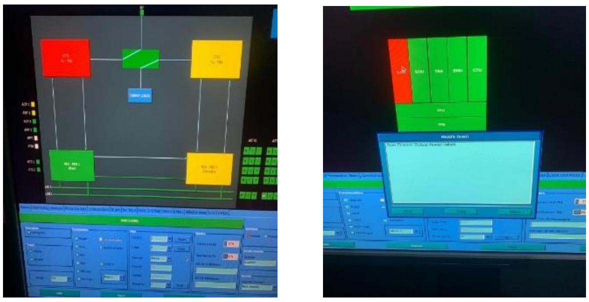

Figure 6. Alarm channel 1 radar INDRA IRS 20 MPS

Problem Analysis find the first to coordinate with the Technical Manager regarding Channel 1 radar alarms. Second, technicians perform physical checks of Channel 1 radar and module checks via SLG by changing Channel 1 mode to the maintenance position. Third, looking at the alarm report history on SLG Radar, the results are as follows: a) There is an SAU SUM Channel Output Power Failure alarm on January 13, 2021, at 19:18 UTC b) Antenna Stopped pada 13 January 2021 at 19.30 c) UTC There is an SAU SUM Channel Output Power Failure alarm on January 13, 2021, at 19:43 UTC.

Figure 7. Channel 1 radar mode maintenance display

2021-01-13 19:11:06	SAU		Sum Channel Output Power Failure
2021-01-13 19:11:10	SAU	Recovery	Sum Channel Output Power Failure
2021-01-13 19:12:00	SAU		Sum Channel Output Power Failure
2021-01-13 19:12:02	SAU	Recovery	Sum Channel Output Power Failure
2021-01-13 19:16:44	SAU		Sum Channel Output Power Failure
2021-01-13 19:18:36	SAU	Recovery	Sum Channel Output Power Failure
2021-01-13 19:18:40	SAU		Sum Channel Output Power Failure
2021-01-13 19:24:36	SAU	Recovery	Sum Channel Output Power Failure
2021-01-13 19:26:44	SAU		Sum Channel Output Power Failure
2021-01-13 19:27:28	SAU	Recovery	Sum Channel Output Power Failure
2021-01-13 19:30:14	PEDESTAL		Antenna stopped
2021-01-13 19:30:14	PEDESTAL		System not ready
2021-01-13 19:43:32	SAU		Sum Channel Output Power Failure
2021-01-13 19:44:08	SAU	Recovery	Sum Channel Output Power Failure
2021-01-13 19:45:04	SAU		Sum Channel Output Power Failure
2021-01-13 19:52:18	SAU	Recovery	Sum Channel Output Power Failure

Figure 8. History alarm report radar INDRA IRS 20 MPS

Fourth, ensure Channel 1 is in the maintenance position and Interrogation mode is off; then, the technician turns off the Channel 1 Circuit Breaker and waits a few minutes before checking the connection. Fifth, the technician checks the back connector of the module; the result is that the connector is well connected. Sixth, then the technician turned channel one back on. Seventh, taking measurements of the TPS voltage, the result is normal voltage. Eighth, the technician changes over channel 1 to main, then activates Interrogation; the result is still an alarm. Ninth, configure parameters and measuring instruments for measurements on the output of the channel 1 module power transmitter by the maintenance manual book. Tenth, the technician changes the Channel 1 mode back to the Maintenance position, then measures are made on the power transmitter output of the Channel 1 module. Eleventh, compare measurement results with references from the maintenance manual book. The measurement results of Mudul Transmitter Channel 1 are as follows: a)CTU Module measurement values and Omni Power Output in TRA modules from levels 1 to 7 are normal. b) SDU Module output measurement values from level 1 to normal level 7 with 62 dBm ± 1db values. c)The measurement values of the SAU Module and the SUM Power Output in the TRA module from levels 1 to 7 are abnormal; the conclusion is that the measurement value on the SAU module is abnormal, and there is an anomaly at each power level.

Figure 9. Display connector behind module

After that, disassembly was carried out on the SAU module to see the condition of the module. The steps are as follows: First, turn off Radar channel 1 to pick up the problematic SAU module so that the Radar at Kualanamu Airport works with a single channel. Second, the technician removed the SAU module from Indra's MSSR rack. After that, the module was dismantled and it was found that the condition of the SAU module had burned. Then the technician takes measurements on the SAU module components that are not burned. In conclusion, the SAU module must be replaced with a spare module. And then checking spare parts owned by the Airnav Medan branch. Because spare parts are not available, the replacement of the SAU module must wait for the arrival of a new module from the head office. The steps to replace the SAU module are as follows: First, coordinating to improve the relevant Leaders and ATC. Second, turn off the Radar according to the procedure. Then, the technician replaces the SAU module with a new one and ensures that the module is installed correctly. Then the radar was turned back on.

Table 1. SOP turns off MSSR Indra IRS-20 MP/S

No.	Activities carried out
1.	Coordination with Users
2.	Checking Environmental Conditions
3.	Turning Off Interrogators and Antennas a. Turn off the interrogator through the menu on the SLG computer b. Turn off the Motor antenna through the menu on the SLG computer
4.	Turning Off Pheriperal MSSR a. Turning Off the VR3000 Computer b. Turning Off the SLG Computer c. Mematikan IAU Module
5.	Turning Off the MSSR Rack/Cabinet
6.	Turning off the power distribution panel
7.	Checking Equipment Safety
8.	Equipment Condition Recording in Log book

Table 2. SOP turns on MSSR Indra IRS-20 MP/S

No.	Activities carried out
1.	Preparation: First, Check environmental conditions. Second, measure electrical resources, and third, check the room temperature. Fourth, checking "Safety Element" / Emergency Stop. Fifth, checking RF Connection on transmitter module module. Sixth, raising the MCB for MSSR equipment on the Power Distribution Panel
2.	Turning on the SLG Computer: First, press the CPU power button and monitor LCD. Second, make sure the SLG computer is normal
3.	Turning on the VR3000 Computer: Press the CPU power button and monitor LCD to make sure the VR3000 computer is normal
4.	Turning on the Rack/Cabinet Interrogator: On the top right rack, raise MCB A, B and C to the ON position
5.	Checking MSSR peripherals: Make sure the IAU module and Hub Switch are on
6.	Enable antennas and interrogators: First, login to SLG with Local control. Second, click on Pedestal to check on motor 1, motor 2, or Both Motor then click Apply. Third, return to Main SLG. Click MSSR Mode S, and click/check the Interrogator
7.	Checking MSSR operational performance on VR3000 displays: Check Track and Label the target aircraft.
8.	Informing the Operational Unit (ATC)
9.	Equipment Condition Recording in Log Book

Continue perform measurements on the power transmitter output of the channel 1 module in accordance with the maintenance manual book. The results of operation of Channel 1 Radar INDRA IRS 20 MPS after replacing the SAU Module.

Figure 10. Show SLG after SAU module replacement

Conclusion

The failure problem on the MSSR at Kualanamu Airport is due to damage to the Sum Amplifier Unit (SAU) module, which causes the SUM output on the Radar to be abnormal. The way to overcome the problem was by disassembling the SAU module for repair and problem analysis, but the results of the analysis found that the module could not be repaired because the module had burned, so it was necessary to replace the Sum Amplifier Unit (SAU) module with a new one, then measurements were retaken and the results were that the radar was operating normally.

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